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An Intelligent Wheelchair Controlled using Keyboard and Accelerometer

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ABSTRACT

This paper describes the design of a wheelchair which is controlled with a Keyboard or Accelerometer. Accelerometer is going to produce different voltages based on tilting. The ADX335 MEMS (Micro Electro Mechanical System) Accelerometer senses the tilt of the hand. According to tilt it will produce voltages are given to microcontroller then the controller gives directions to Relays in the board. The Relays in the board will decides direction of wheelchair by ON/OFF corresponding motors. And also it can be controlled by using Arrow keys in the keyboard i.e. (Up. Down, Left, Right). Based on Arrow keys pressed on key board the corresponding direction of wheelchair is going to be change. Advantage of wheelchair is cost is low, power consumption of batteries is less, we can control easily, Complexity of design is less.

Keywords: ADXL335 Accelerometer, Keyboard, Fabricated Wheelchair, Battery, DC Motors, GSAS 51E Microcontroller Board, GSAS ADC0816

INTRODUCTION

The current electric powered wheelchairs are mostly joystick-driven, and cannot fully meet the need of the disabled and elderly people whose autonomies are seriously affected by decline in their motor function and cognitive performance. Up to now, various hands-free HMIs (Human Machine Interfacing) have been developed for the disabled and elderly people to control electric powered wheelchairs by using shoulder, head and tongue motion, as well as eye tracking. Jia et al [7] developed a visual based HMI for controlling a wheelchair by head gestures which were recognized by detecting the position of the nose on user's face. Gajwani and Chhabria [2] used eye tracking and eye blinking obtained by a camera mounted on a cap to control a wheelchair. However, the performances of these HMIs are likely affected by environmental noises such as illumination, brightness, and the camera position. Additionally, eye tracking may force and affect the vision of the user, causing tiredness and dizziness.

The NavChair Assistive Wheelchair Navigation System, The NavChair shares vehicle control decisions with the wheelchair operator regarding obstacle avoidance, safe object approach, maintenance of a straight path, and other navigational issues, to reduce the motor and cognitive requirements for operating a power wheelchair [10]. On the other hand, some researchers have used electromyography signal (EMG) for controlling wheelchairs by performing certain shoulder movements. Han et al. [4] used four EMG electrodes on the Stenocleidomastoid muscle in order to detect three shoulder movements (both shoulders up, right shoulder up and left shoulder up), achieving an average success rate of 91.2%. While Moon et al. [8] only used two EMG electrodes to detect shoulder movements in order to control the wheelchair. Unfortunately some disabled people may not be able to move their shoulders and bodies, alternative ways are required. Huo and Ghovanloo [6] operated a wheelchair by using tongue movements, in which the movement data was obtained from a magnetic tracer on the tongue. This is a little invasive for long-term usage since the user should receive a tongue piercing embedded with the magnetic tracer. Palankar et al. [9] controlled a wheelchair by using a mounted robotic arm in a simulated environment. The robotic arm was operated by means of a P300 brain computer interface (BCI), in which the user was able to control the motion of the arm and chair by focusing attention on a specific character on the screen. Nevertheless, the response time of the BCI needs to be improved for a real world. Touch Screen Based Direction and Speed Control of Wheel Chair for Physically Challenged, when we want to change the direction, the touch screen sensor is modelled to direct the user to required destination using direction keys on the screen and that values are given to micro-controller. Depending on the direction selected on the touch screen, micro-controller controls the wheel chair directions [11].

Recently, a new EEG sensor, Emotive EPOC, has been available on the market to provide potential applications on hands-free HMIs. It has three suites: ‘cognitive suite’ to detect thoughts, ‘expressive suite’ to detect facial expressions and ‘affective suite’ to detect emotions, as well as a gyroscope to detect head movements. In [3], it was used to recognize four trained muscular events to steer a tractor: (i) eyes looking to the right and jaw opened, (ii) eyes looking to the right and jaw closed, (iii) eyes looking to the left and jaw opened, and (iv) eyes looking to the left and jaw closed. Carrino et al. [1] developed a system, namely “Virtual Move”, which allows users to navigate through Google Street View (GSV) using head movements, facial expressions, thoughts and emotional states.

This paper presents the concept of a wheelchair which consists of 3axis accelerometer, Key board, LCD display, DC motors, Relays, and an AT89C51 Microcontroller. A disabled person can control the motion of wheelchair using Accelerometer which has in hands and in another mode by using Keyboard. Based on the tilt in Accelerometer the corresponding changing voltages are collected by microcontroller then it sends control signals to relays. The Relays will ON the corresponding DC Motors. In similar manner the signals received from keyboard Arrow buttons directions of wheelchair are going to be change using relays.

DETAILS OF COMPONENTS

Microcontroller Board

An Embedded System employs a combination of hardware & software (a “computational engine”) to perform a specific function**.** The 8051 provides the following standard features: 4Kbytes of ROM, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, five vector two-level interrupt architecture, a full duplex serial port, and on-chip oscillator and clock circuitry. In addition, the 8051 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

The main **features** of this GSAS 51E are:

- GSAS 51E operates on single +5V power supply either stand – alone mode or with host PC through its USB or RS-232C interface in serial mode.
- Stand-alone and serial monitor, support the entry of user programs, editing and debugging facilities like single stepping and full speed execution of user programs.
- On-board memory is 128K bytes of which 88 Kbytes RAM has battery backup provision.
- Total on-board memory is 128K bytes of which 88K bytes RAM has battery backup provision.
- 48 I/O lines and four programmable interval timers.
- 9 Port lines of MCU brought out to the right angle ribbon cable connector including INT1.
- Buffered Bus Signals are available through flat ribbon cable connector for easy system expansion.
- Driver Software for file upload/download to/from host PC.

Keyboard

In this project we have used the key board as system uses keyboard. In this keyboard we are using only the Arrow keys.

Analog to Digital Converter

ADC0816 is 16 Channel, 8-bit ADC (Analog to Digital Converter). The interface has 20 pin terminal strips to feed in the analog voltages; the input signal voltage range is 0-5V. Standard hermetic or moulded 40-pin DIP package, Its Temperature range −40°C to +85°C or −55°C to +125°C. The 16-channel multiplexer can directly access any one of 16-single-ended analog signals, and provides the logic for additional channel expansion. Signal conditioning of any analog input signal is eased by direct access to **°C** the multiplexer output, and to the input of the 8-bit A/D converter.

ADXL335

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer. We have used ADXLL335 accelerometer. An Accelerometer is a kind of sensor which gives an analog data while moving in X, Y,Z direction .It is having six pins those are Vcc, GND, ST (self Test). Operation: 1.8v to 3.6v.

Motor Drivers and Motors

Here motor driver circuit is the H-Bridge. We used Relays for changing directions of motor and ON/OFF of Corresponding motor. We used 24V Series DC motors. The direction of rotation of a series motor can be changed by changing the polarity of either the armature or field winding by using Relays. The motor are 24 Volt, 12 Nm Torque,1 & 2 speed heavy duty rocker switched available, Adjust wiper angles from 40˚ to 130˚.

Battery
The Motors of wheelchair is going to take 24v as Input. So are using four chlorides safe power sealed acid battery. Each motor will be connected to two 12v, 7Ah battery. Two batteries are connected Serial Manner to get 24v for driving motors. These batteries are rechargeable.

Display
Here we have used 4X16 Liquid Crystal Display (LCD) for showing corresponding direction messages. It can display English-European Characters.

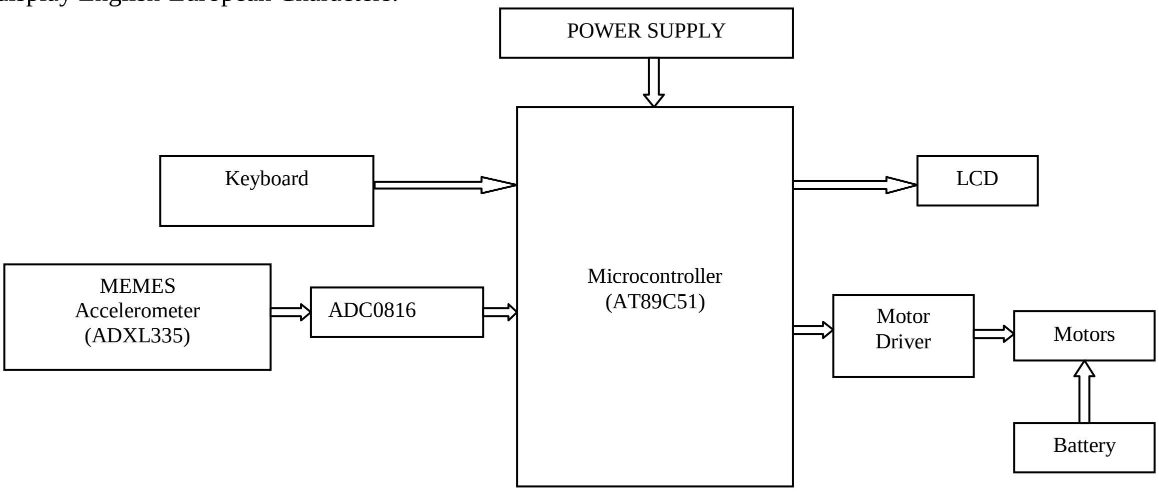


Fig. 1 System Block diagram

METHODOLOGY

The wheelchair is going to be controlled two modes. One is Accelerometer and other one is Keyboard mode. Initially we have to decide which mode we want to control wheelchair. Based on the given condition it is going to be operated. We measure the value of 3-Axis accelerometer (ADXL335) based on the hand movement and converted into digital with the help of ADC 0816. Microcontroller gets the hex data from the accelerometer. LCD display the corresponding directions Messages i.e. Left for –X direction, Right for +X direction, Forward for +Y direction, Back for –Y direction and Remaining any condition it will stop. At the same time microcontroller gets the data and compare inside with pre-defined values. As we change the position of hand, values are going to change automatically and corresponding messages are shown on the LCD. Another mode of operation is keyboard. If we used keyboard here we have four Arrow Keys in our Keyboard. Those are Up, Down, Left, Right. Up Arrow- Forward Direction, Down Arrow- Backward Direction, Left Arrow- Left Direction, Right Arrow – Right Direction, other than that any key presses it will be going to stop. ASCII values and corresponding Hex Values of Arrow are given below table.

Table -1 Keyboard ASCII and Hexadecimal values

Arrows	Decimal	Hex
Forward-	24	18
Backward-	25	19
Right-	26	1A
Left-	27	1B

Table -2 Directions indication of Accelerometer

Direction	**Accelerometer orientation**
Forward	+Y
Backward	-Y
Right	+X
Left	-X
Stop	Rest

Table -3 Relays ON/OFF Conditions

Left motor	Right motor	Direction
ON (CW)	ON (CW)	Forward
ON (CCW)	ON (CCW)	Backward
ON (CW)	OFF	Right
OFF	ON (CW)	Left

In accelerometer we are getting 1.40v maximum for Positive X, Y directions, then 0.95v minimum voltage for negative X, Y directions, for stable condition we are getting 1.14v. So by using these values we have given conditions to microcontroller board to control wheelchair. Accelerometer giving analog values but the microcontroller will takes only hexadecimal values. For that we have used 16 channel ADC0816 board. Here we are taking ch1, ch2, and ch3 in ADC0816 for Xout, Yout, and Zout respectively. The reference voltage we set for ADC0816 board is 3v. Here also we have used the Assembly language program. We have written a code as if arrow keys pressed in keyboard each key has its ASCII (American Standard Code for Information Interchange) value. So for corresponding pressed key ASCII values are taken. Before that we have written a code to store ASCII value of four Arrow keys in a memory location and we also written a comparison program. Whenever the key pressed in keyboard corresponding ASCII values are going to be compared. If it matches with the Hex Value of ASCII code then the corresponding signal is going to send to Relays of Board. Then the relays are going to ON/OFF relater Motors of Wheels.

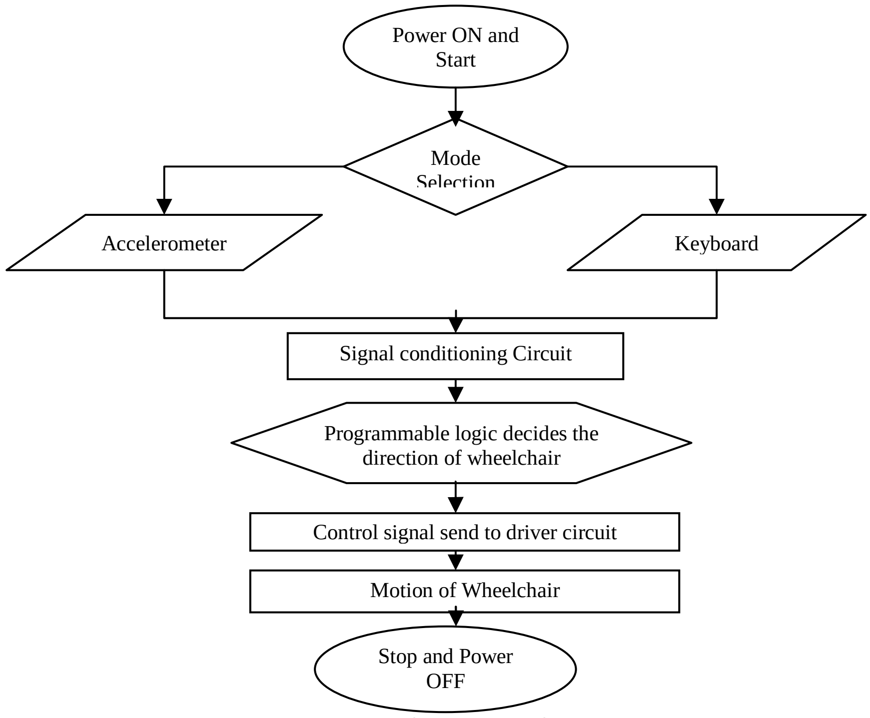


Fig. 2 Flow Chart for Selection of mode

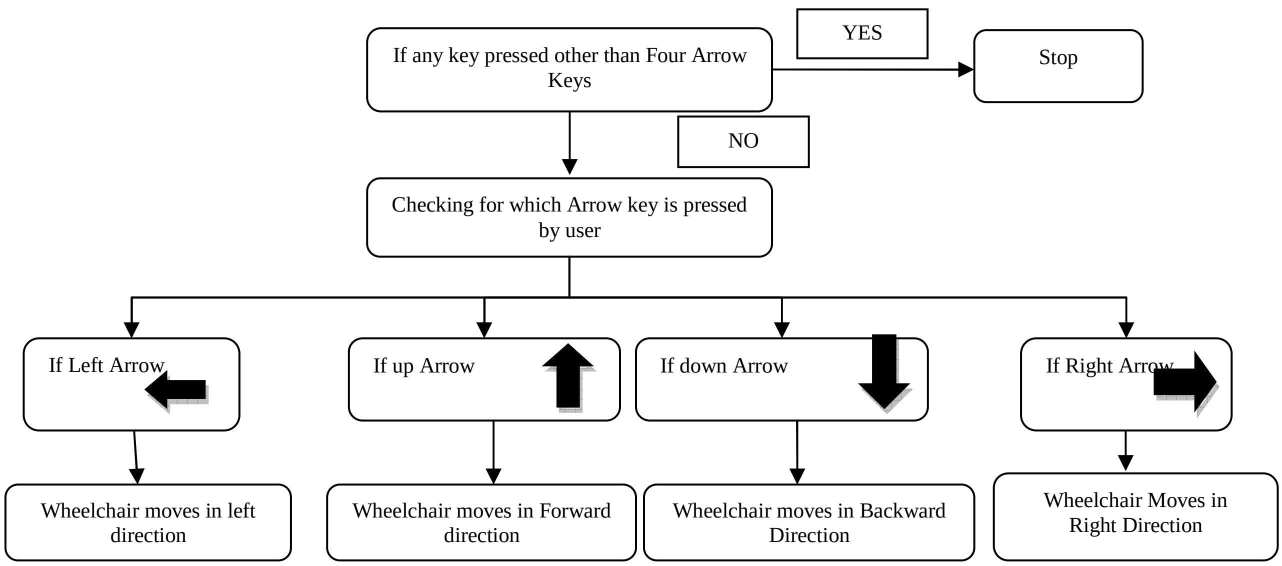


Fig. 3 controlling of wheelchair using keyboard Flow chart

We have written code for controlling of wheelchair is Assembly language programming. So we have written the code for analog to digital conversion of Accelerometer output analog data. When we get the analog data for accelerometer it is converted in to digital and stored in the memory location of microcontroller is 8190,8191,8192 locations of X,Y, Z respectively. There is no need for ADC (Analog to Digital Conversion) program we can directly get the hex values of Arrow keys. We are storing these values in same memory location. There is no problem of using same memory location because when we operate one mode in wheelchair we can use same memory location. Then after we have written comparison program by using these values and predefined values in the program. If the values we get from accelerometer or keyboard is matched with the predefined values, then corresponding direction message is going to displayed in the LCD display of GSAS 51E board and corresponding DC motors relays are going to be ON/OFF. We have written assembly language program for corresponding relays ON/OFF.

Table shows the relays ON/OFF conditions. Based on outputs of two modes of program transistors will ON and OFF and corresponding motors will ON/OFF also direction will be decides. The hardware connection of relays to two DC Motors is shown below. We have soldered these relays according to our requirement. We have connected 24V DC Motors Two relays for each motor in that one is for ON/OFF; another one is for Direction change. Based on the given input the relays are going to respond for two modes of operation. Below diagrams are going to show key board operations and corresponding messages are going to displayed on the LCD display. Here we have connected a keyboard to GSAS 51E board with cable wire. Based on the arrows given from the keyboard the wheelchair directions are going to change.

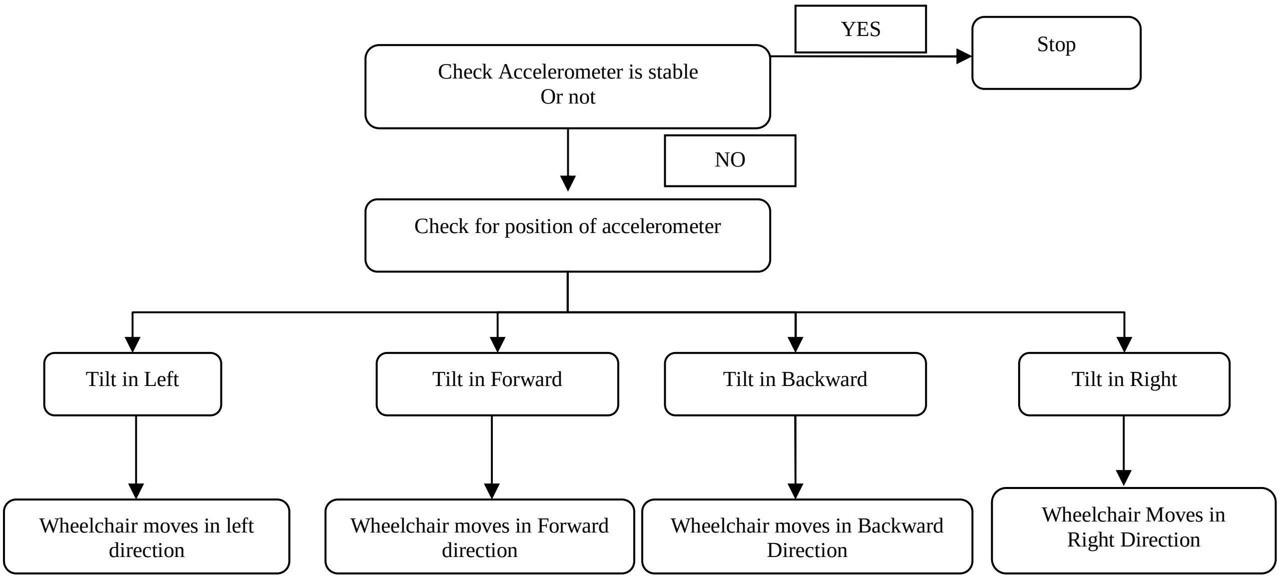


Fig. 4 controlling of wheelchair using Accelerometer flow chart

Fig. 5 Four Relays are connected to two Motors

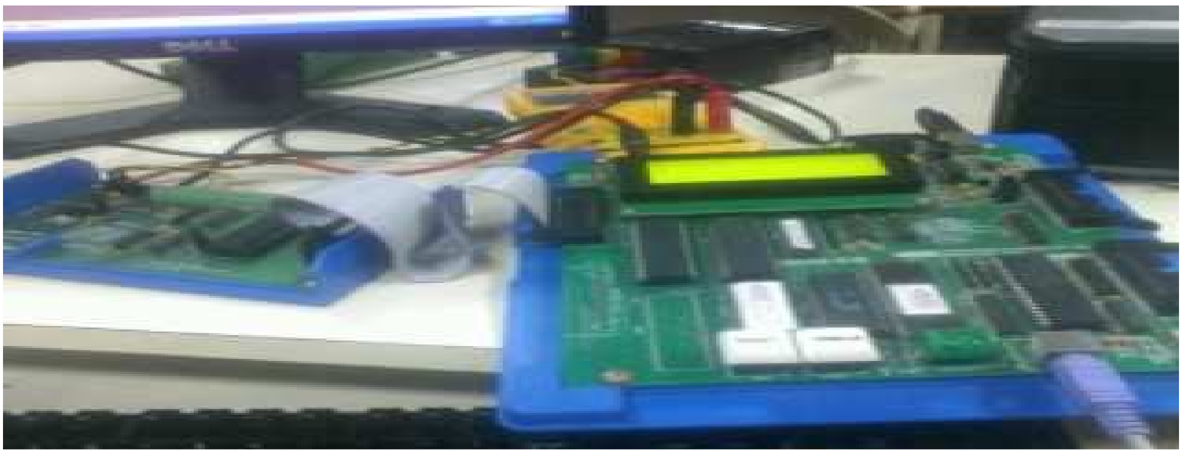
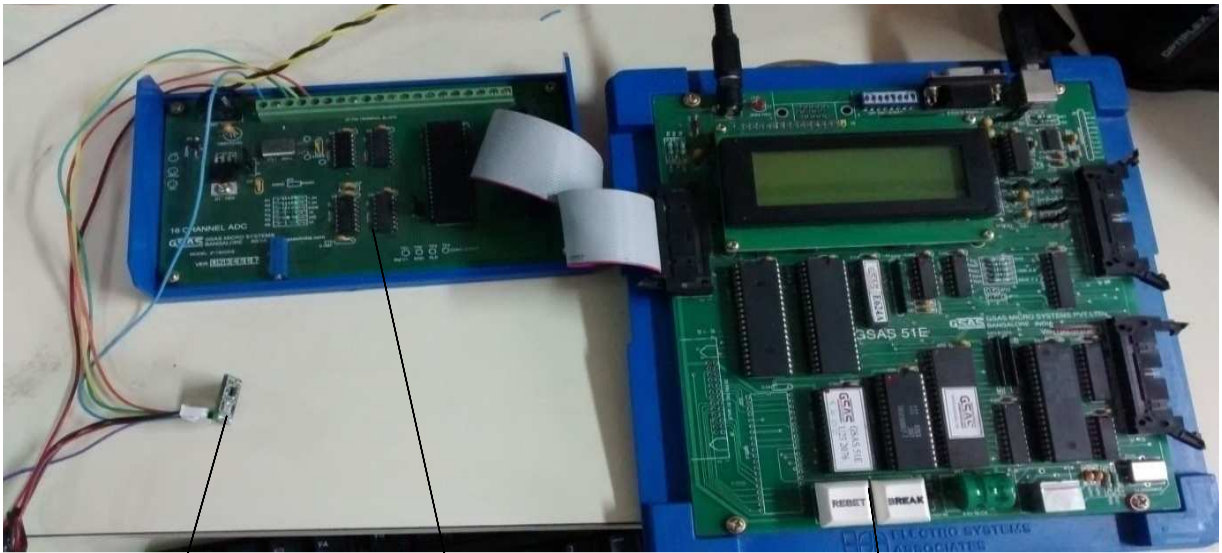


Fig. 6 GSAS 51E board connected with Keyboard

Keyboard connecting cable

Fig. 7 Keyboard controlled wheelchair complete hardware interconnections

Fig. 8 Keyboard given Direction Arrows to wheelchair corresponding messages in LCD



ADXL335 (Accelerometer) ADC 0816 Board GSAS 51E Microcontroller Board

Fig. 9 Hardware interfacing of Accelerometer, ADC0816 and GSAS51E Board

Fig. 10 Complete hardware interfacing of Accelerometer controlled wheelchair

Fig. 11 Hardware structure of wheelchair without using keyboard or Accelerometer

CONCLUSION

It uses hand movements detected by the motion data obtained from the Accelerometer or we can use keyboard for controlling of wheelchair. It has two control modes, one mode uses only one hand movement ('Forward' or 'Backward' or 'Left' or 'Right') and the other one employs four Keyboard movements ('up', 'down', 'right' and 'left'). Four control commands were implemented, namely 'going forward', 'turning right', 'turning left', 'going backward', any key pressed or other than directions indicated above in Accelerometer wheelchair will stop . In both control modes, the user does not have to maintain the hand movement during the control command. Experimental results show that the proposed Accelerometer or keyboard of controlling a wheelchair is reliable.

This Wheelchair will be economical and can affordable to common people. This system can be made highly efficient and effective if stringent environmental conditions are maintained. The running cost of this system is much lower as compare to other systems used for the same purpose. Our work is to control Wheelchair by accelerometer or Keyboard where the wheelchair is programmed to reacts according to the motion of accelerometer (forward, reverse, stop, left and right). The movement is recognized by ADXL335 is used to control the motion of the Wheelchair. Also the accelerometer sensor is calibrated such that it produces particular analog voltage for a corresponding tilt and also corresponding arrow keys given from the keyboard the wheelchair has to change its directions.

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